PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION

Improvements in Lead-in Conductors for Transformers, Switchgear and like Electrical Apparatus Enclosed in Metal Casings

We, HAROLD SMETHURST, of 147, Victoria Road, Fallowfield, Manchester, in the County of Lancaster, FRANK EDMUND BANCROFT, of 19, Delaine Road, Withington, Manchester, in the County of Lancaster, GODFREY BURROWS, of "Lynton", Fownhope Avenue, Sale, in the County of Chester, all subjects of the King of Great Britain, and ASSOCIATED ELECTRICAL INDUSTRIES LIMITED, of Crown House, Aldwych, in the City of Westminster, a British Company, do hereby declare the nature of this invention to be as follows:—

This invention relates to lead-in conductors for transformers, condensers, switch-gear and like electrical apparatus enclosed in metal casings and taking heavy currents. In such apparatus difficulties arise by reason of induction heating of the metal casings such as oil tanks, from the lead-in conductors, particularly in the case of currents of high frequency such as of 1000 or 10000 cycles per second as are commonly used in coreless induction furnaces, the invention being notably applicable in metal-clad apparatus supplying such furnaces. The invention however is not limited to high frequency apparatus, since undesirable induction or eddy-current heating of the tanks of 50 cycle transformers often arises. To reduce such heating the use of aluminium has been resorted to, at least for those parts of tanks or casings which tend to become heated inductively due to the current in the lead-in conductors.

The present invention provides a construction of lead-in conductors in which the aforesaid heating is avoided or minimised, and subordinately, lead-in conductors which may be themselves cooled by circulation of a cooling fluid through them.

The construction of the lead-in conductors is per se that used in the vacuum furnaces described in prior co-pending Applications Nos. 1814/33 (Serial No. 413,698) and the divisional Application No. 19323/34 (Serial No. 414,054), such vacuum furnaces being excluded from the scope of the present Application, which, in other words, extends the scope of said earlier co-pending Applications, so far as the lead-in conductors are concerned, to other apparatus than the particular vacuum furnaces forming the subject thereof, namely to transformers, condensers, switch-gear and other like enclosed apparatus, the metal casings of which become inductively heated undesirably by the currents flowing in the lead-in conductors.

The coaxial lead-in conductors possess the further advantage of material saving in space.

It is to be understood that the present invention is not limited to lead-in conductors constructed for the circulation of cooling fluid therethrough.

In the case of evacuated apparatus such as an evacuated condenser, a metal collar may be secured to the inner end of either or both lead-in conductors so as to provide a gap less than the mean free path in the residual atmosphere.

If it is desired to cool the lead-in conductors in cases wherein the internal electrical apparatus is not itself fluid-cooled, the inner lead-in conductor may be a tube having one or several perforations at its inner end communicating with the annular space between the conductors and oil or other insulating liquid may be circulated, or water may be circulated if the flow paths are duplicated and arranged independently of each other so as to avoid electrolysis.

Dated the 18th day of July, 1934.

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COMPLETE SPECIFICATION

Improvements in Lead-in Conductors for Transformers, Switchgear and like Electrical Apparatus Enclosed in Metal Casings

We, HAROLD SMETHURST, of 147, Victoria Road, Fallowfield, Manchester, in the County of Lancaster, FRANK EDMUND BANCROFT, of 19, Delaine Road,

Withington, Manchester, in the County of Lancaster, GODFREY BURROWS, of "Lynton", Fownhope Avenue, Sale, in the County of Chester, all subjects of the King of Great Britain, and ASSOCIATED ELECTRICAL INDUSTRIES LIMITED, of Crown House, Aldwych, in the City of Westminster, a British Company, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to lead-in conductors for transformers, condensers, switchgear and like alternating current electrical apparatus enclosed in metal casings and taking such heavy currents and/or currents of such frequency that difficulties arise by reason of induction heating from the lead-in conductors, of the metal casings such as oil tanks, furnace casings, switchgear walls and condenser chambers, such difficulties particularly arising in the case of currents of 500 or more amperes and of frequencies such as of 1000 or 10000 cycles per second as are commonly used in coreless induction furnaces, the invention being notably applicable in metal-clad apparatus supplying such furnaces. Thus in the vacuum furnaces claimed in the Specification of Letters Patent Nos. 413,698 and 414,054, a coaxial construction of the lead-in conductors was employed to avoid undesirable heating of the furnace chamber. Such vacuum furnaces are excluded from the scope of the present application. The invention, however, is not limited to high frequency apparatus being applicable to other apparatus such as transformers, condenser, switchgear and like electrical apparatus of the kind requiring metal enclosures, tanks or casings which, in the absence of the present invention applied thereto, would become inductively heated impermissibly by the relatively heavy currents flowing in the lead-in conductors. To reduce such heating the use of aluminium, brass and stainless steel has been resorted to, at least for those parts of tanks or casings which would become heated inductively due to the current in the lead-in conductor or alternatively fluid-cooling of these parts has been resorted to. For similar purposes the heating has been prevented or reduced by avoiding closed secondary circuits, namely by making saw-cuts or adding inserts of insulating material, which methods are in general inconvenient.

No claim is herein made to coaxial lead-in conductors per se, since we are aware of two prior proposals involving the use thereof in connection with apparatus enclosed in tanks, namely Specifications of lapsed Patents Nos. 187,027 and 144,191 (Fig. 2), the invention which formed the subject of the latter patent being further disclosed in the American publication "General Electric Review", November 1919, pages 865—875.

Specification No. 187,027 discloses a circuit breaker in which, for avoiding lateral displacement of relatively long lead-in contact stems by the magnetic repulsive forces due to heavy currents, said stems are in the form of coaxial members insulated from one another and each having mounted on its end a fixed contact with which a moving bridge co-operates. This Specification contains no mention of the induction heating of the circuit breaker head or cover. No circuit breakers in accordance with this Specification were commercially made by the Applicant Company, nor so far as we are aware, by anyone else. Such circuit breakers are excluded from the scope of the present invention which is however applicable, for the purpose of avoiding the induction heating of metal casings or cover members to impermissible extent of heavy and/or high frequency current circuit breakers and switches wherein the fixed contacts are not directly carried by the ends of the respective coaxial lead-in members.

Regarding Specification No. 144,191 and the article in General Electric Review aforesaid, these disclose arrangements, which so far as we are aware have not been commercially used in England, whereby two part tubular high voltage insulator bushings of standard dimensions and clearly for many thousands of volts, can be adapted for use in various kinds of apparatus, including circuit breakers, lightning arresters, power transformers, and current and potential metering transformers. The arrangements to this end involve inter alia a metal tie tube arranged coaxially within two aligned bushing portions and having attached to it at each end a cap engaging the outer end of a bushing portion, the adjacent ends of the bushing portions being secured to the metal tank or casing through a hole in which the bushing passes. Thus for a circuit breaker said tie tube may carry at the outer end a terminal and at the other end one of the fixed contacts, the other of which is mounted in a similar manner. For a lightning arrester or a transformer a conductor, such as a flexible insulated conductor from the windings can be brought up the tie tube and connected with a terminal cup or member at the upper end thereof. Whilst these applications

involve in effect a single conductor passing through the bushing, according to a fourth proposal, mentioned as applied to serve metering apparatus as for instance current metering transformers and potential metering transformers in the specification, and illustrated in Fig. 2 thereof, but applied only to current metering transformers in the aforesaid article, the tie tube serves as one lead-in conductor and carries coaxially within it and insulated from it a return conductor in the form of a rod, the rod and the tube each having a terminal secured to it at both ends. Whilst again these publications make no mentioned of any avoidance of induction heating of the tanks or casings, since obviously impermissible heating thereof would not be expected, the specific arrangements disclosed are disclaimed from the scope of the present invention which clearly is not limited to high voltage bushings nor even to the use of bushings.

Subject to the above three disclaimers the present invention comprises, for the purpose set forth, the combination with an apparatus of the kind hereinbefore specified and its tank or casing, of a lead-in conductor assembly secured to the metal casing of the apparatus, and comprising a pair of coaxial conductor members insulated from one another and having terminals located or adapted to be located outside the casing, it being understood that the apparatus is constructed for such heavy currents and/or such high frequencies that with the use of the ordinary separated lead-in conductors the tanks or casings would become so greatly heated by induction from said lead-in conductors as to cause trouble such as the boiling of oil, the warping of joints, the distortion of parts with the possible cracking of insulator bushings, the impairment of insulation and so on, which troubles would give rise to faults and repairs, which defects have heretofore been prevented, as aforesaid, by the use of aluminium or brass or stainless steel for the tank or casing parts in question or the cooling of these parts by fluid circulation or by preventing closed secondary circuits.

The invention also comprises, subject to the first but irrespective of the second and third of the foregoing disclaimers, a lead-in conductor assembly secured or adapted to be secured to the metal casing and comprising a pair of coaxial conductor members insulated from one another and having terminals located or adapted to be located outside the casing, the arrangement being such that the coaxial conductors can be cooled by the circulation of fluid therein.

In order that the invention may be clearly understood and readily carried into effect a number of particular fluid cooled lead-in conductor assemblies in accordance therewith will now be described by way of example with reference to the accompanying drawing in which:—

Fig. 1 is an elevation, mainly in section, of an embodiment of the invention, having an insulating bushing by which it is mounted in a container and adapted to be cooled by oil or other insulating fluid,

Fig. 2 is a similar view of an embodiment of the invention adapted to be water cooled, and

Fig. 3 is a half sectional elevation with the middle portion broken away, illustrating an alternative embodiment of the invention.

Referring first to Fig. 1, a portion of the metal container of an electrical apparatus (not shown) is indicated at 1, having a perforation at 2 through which the conductor assembly extends. A bushing 3 of insulating material is mounted in place over said perforation 2 such as by means of a clamping ring 3*a*. The bushing 3 surrounds a main body portion 4 of metal of the lead-in conductor assembly, said body portion being provided at its lower end with a flange 5 and intermediately at 5*a* with a screw thread with which engages a clamping ring or nut 6 which, in conjunction with the flange 5, serves to secure the lead-in conductor assembly in place in the bushing 3. Suitable gaskets or washers are provided at 7 and 7*a*. The outer lead-in conductor is formed partly by the body portion 4 and is completed by a tube 8 welded or soldered to the flange 5, as shown, whilst the inner conductor consists of a metal tube 9 which at its upper end extends through a block 10 of insulating material having a recess which engages with a shoulder formed at 11 on the body portion 4. The lower end of the tube 9 is closed by means of a metal member 12 having a screw-threaded portion 13 constituting the inner end of the terminal and to which one side of the electrical apparatus may be connected. Said member 12 is provided with a flange 14 which engages with a flanged tubular insulating member 15 which also engages with a metal ring 8*a* welded or soldered to the lower end of the metal tube 8, the block 15 being suitably flanged at 16 in order to provide the required longitudinal and axial registration of the parts.

The upper end of the inner tube 9 is screw-threaded as indicated and a nut 17

is threaded on to said upper end of the tube 9 whereby the parts are held in the required position. Washers or gaskets 18 and 19 may be interposed between the nut 17 and block 10, on the one hand, and the block 10 and the body portion 4, on the other hand. Further washers or gaskets may be provided at the lower end of the assembly as indicated at 20 and 20*a*.

A pair of terminal nuts 21 are also threaded on to the tube 9 at the upper end of the latter, whilst said upper end is formed with a nozzle 22 whereby a hose pipe connection may be made with said tube 9 for the fluid cooling of the lead-in conductors. Perforations 23 are provided in the lower end of the tube 9 whereby the space within said tube 9 is placed in communication with the annular space between the tubes 9 and 8 and thence with the annular space between the tube 9 and the body portion 4. An opening 24 is formed in the body portion and adapted to receive a second nozzle (not shown) for receiving a second hose pipe connection whereby the circuit of the cooling fluid through the lead-in conductor assembly is completed. A screw-threaded recess 25 is also provided in the body portion 4 and adapted to receive a terminal (not shown). A terminal member 26 having a screw-threaded portion 27 to which the other end of the electrical apparatus within the casing 1 may be connected, is secured to the lower end of the tube 8, for example by welding, or said member 26 may be formed as a split clamp.

With the arrangement shown in Fig. 1 the cooling fluid which may be oil or air or a suitable gas, must be an insulating fluid, and the arrangement is therefore not adapted to water cooling since the lead-in conductors would be short-circuited by the cooling water.

In carrying out the invention for providing cooling of the lead-in conductors by water, according to one example, three coaxial tubes arranged in the general manner illustrated in the specifications of Letters Patent Nos. 413,698 and 414,054 aforesaid are employed. At the inner end of the lead-in conductors, namely the end of the latter within the metal casing, the space between the outermost tube and the intermediate tube, is connected with the interior of the innermost of the three tubes by means of a coiled tube which may be of metal and which provides a path of sufficiently high electrical reactance combined with a low water impedance. Conveniently these conditions may be fulfilled by tuning said coiled water carrying tube to the frequency of the electrical supply to the apparatus by means of a condenser. In this arrangement the water circuit may advantageously be arranged to include the electrical apparatus supplied by the terminal where such apparatus is of a kind adapted to be cooled by the passage of water through it. The coiled tube, when of metal, may be connected electrically and hydraulically in series with such apparatus, or may be constituted entirely by such apparatus, as in the case of a furnace coil for example. In some cases the water connection between the tubes of the terminal as above indicated may be completed by a cooling passage through the electrical apparatus connected across the conductors of the terminal, said passage being arranged so as to prevent an undue flow of current through the water and to avoid undue electrolysis of the latter. In an alternative arrangement said water connection is formed by a duct of insulating material, for example a rubber pipe, which is of reasonable length in relation to the voltage between the terminals to prevent an undue flow of current through said duct. In a modification of the arrangements as just above described, the inner tube of the outer conductor is replaced by a suitable insulating covering, for example a coating of the material known under the Registered Trade Mark as " Insuloid ", on the outer surface of the central tubular conductor.

Fig. 2 shows a water-cooled arrangement of lead-in conductor assembly in accordance with the invention, in which five coaxial tubes are used so as to provide two distinct fluid cooling paths for the lead-in conductors. In Fig. 2 a portion of the metal container of the apparatus is again indicated at 1, the outer conductor of the terminal being connected directly with said container instead of being supported by means of an insulating bushing as in Fig. 1. In Fig. 2 the electrical apparatus is assumed to be located above the portion 1 of the container, that is to say the terminal extends through the bottom of the container. One of the coaxial lead-in conductors is constituted by a pair of tubes 28 and 29 which are welded together at the ends of the latter. A closing member 13 having a screw-threaded portion is provided for the upper end of the tube 28 the lower end of which is formed as a nozzle 22 and provided with terminal nuts 21 as in Fig. 1. The tube 29 is provided with a nipple 30 for receiving a hose nozzle for completing a cooling circuit through the tubes 28 and 29, the former being provided at its upper

end with perforations 31. The tubes 28 and 29 are surrounded by three further coaxial tubes 32, 33 and 34, the tubes 32 and 34 being welded at each end to the tube 33. Said three tubes constitute the other lead-in conductor of the assembly. A flanged metal collar 35 is secured to the upper end of the tube 29 whilst a sleeve 36 is secured to the lower end of said tube, said sleeve being provided with a screw-thread at its lower end. Metal collars or flanges 37 and 38 are secured at each end of the tube 33. Flanged collars or sleeves of insulating material are provided at 39 and 40. The insulating collar 39 serves to register the member 37 with respect to the flange 35 whilst the insulating collar 40 engages on the one hand with the member 38 and on the other hand is engaged by a washer 41, the whole assembly being secured in place by means of a locking ring or nut 42 threaded on to the sleeve 36. A nipple is provided at 43 for receiving a hose nozzle for leading the cooling water into the annular space between the tubes 32 and 33, and a further nipple 44 is provided for receiving a further hose nozzle for leading said water away from the annular space between the tubes 33 and 34, said annular spaces being placed in communication with one another at the inner end of the conductor assembly by means of perforations 45 formed in the tube 33. Washers or gaskets may be provided as indicated at 46 and/or at 47.

The conductor assembly is mounted in place in the container 1 by means of a flanged collar 48 which is secured to the said container, a suitable gasket or washer being interposed at 7*a* if necessary. The metal ring 37 is provided with a screw-threaded extension 49 forming the other terminal by which the electrical apparatus (not shown) is connected with the outer lead-in conductor.

As will be obvious, the arrangement shown in Fig. 2 may, if desired, be mounted within an insulating bushing in a similar manner to the embodiment of the invention shown in Fig. 1.

It will be seen that with the arrangement shown in Fig. 2 the tubes 32, 33 and 34 are insulated electrically from the tubes 28 and 29 by means of the insulating members 39 and 40. The individual cooling of the tubes 28 and 29 on the one hand and the tubes 32, 33 and 34 on the other hand, forming the respective lead-in conductors, may be effected for example from independent supplies of water or from the same source through branched insulating hose which may be made long enough or through piping, which may be of metal, formed as electrical choke coils in known manner to insulate for the voltage between the two lead-in conductors and to prevent undue electrolysis.

According to a modification of the just above described arrangement four tubes are employed of which the innermost one is a metal tube constituting one of the lead-in conductors whilst the next adjacent tube is formed of insulating material or is provided on at least one surface with an insulating covering the remaining tubes being of metal and constituting the outer lead-in conductor.

Fig. 3 shows one such arrangement, similar reference numerals being used where possible to indicate similar parts as in Fig. 2.

In the arrangement shown in Fig. 3, the tube 29 is provided with a covering 50 of a suitable insulating material which extends over the surface of a collar 35*a* secured at the upper end of the tube 29. The covering 50 may be a separately fabricated tube placed over the tube 29 or may advantageously comprise a coating of a suitable insulating material applied direct to the said tube and may for example, comprise the material known under the Registered Trade Mark as "Insuloid".

The tube 32 of Fig. 2 is dispensed with whilst the metal ring 38 and the insulating block 40 are formed in the manner shown so as to constitute a stuffing box or gland, packing material being indicated at 51. The insulating member 39 is a plain annular disc whilst suitable washers or gaskets are provided at 46 to render the terminal water-tight at the upper end. With this arrangement the cooling path for the central conductor lies through the tube 28 and the annular space between said tube and the tube 29 similarly to the arrangement shown in Fig. 2, whilst the flow path for the outer conductor lies through the annular space between the insulating covering 50 and the tube 33 and the annular space between the latter and the tube 34.

Where the lead-in conductor assemblies in accordance with the invention are to be employed in evacuated apparatus suitable vacuum seals will be provided where necessary, such as in the construction shown in the Specifications of Letters Patent Nos. 413,698 and 414,054 aforesaid, or between the tubes 29 and 33 of the arrangements herein described with reference to Fig. 2 of the accompanying drawings. Such seals may, for example, be arranged generally in the manner described in said earlier Specifications, the cup-shaped or

equivalent member for retaining the vacuum sealing material preferably being formed, more especially in the case of a lead-in conductor assembly for use with a comparatively high frequency, of a material which is insulating at the frequency for which the assembly is employed.

It is to be understood that the above described arrangements are given only by way of example, and that various modifications may be made without departing from the scope of the invention, which moreover is not limited to lead-in conductors constructed for the circulation of cooling fluid therethrough.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed we declaare that what we claim is:—

1. The combination, for the purpose set forth, with an electrical transformer or condenser or switchgear or other like electrical apparatus as hereinbefore specified (other than a vacuum electric furnace, and other than the electric switch as disclosed in Specification No. 137,027 and other than a metering transformer having lead-in conductors arranged as disclosed with reference to Fig. 2 of Specification No. 144,191), of a lead-in conductor assembly secured to the metal casing of the apparatus, comprising a pair of conductor members insulated from one another and having terminals located or adapted to be located outside the metal casing and of which conductor members one is a tube co-axially surrounding the other conductor member, said two conductor members being adapted to lead the current through said casing to and from respective terminals of the enclosed apparatus.

2. In or for use in an electrical transformer or condenser or switchgear or other like electrical apparatus as hereinbefore specified (other than a vacuum electric furnace) a lead-in conductor assembly secured or adapted to be secured to the metal casing of the apparatus, comprising a pair of conductor members insulated from one another and having terminals located or adapted to be located outside the metal casing and of which conductor members one is a tube co-axially surrounding the other conductor member, said two conductor members being adapted to lead the current through said casing to and from respective terminals of the enclosed apparatus, and said conductor members being adapted for the circulation of a cooling fluid therein, for the purposes mentioned.

3. A lead-in conductor assembly as claimed in claim 2, in which the central conductor member is of tubular form and the outer conductor member comprises a pair of co-axial tubes, the annular space between which is adapted to constitute a flow path for cooling water and is connected or adapted to be connected with the tubular central conductor member at the inner end of the conductor assembly substantially as hereinbefore set forth.

4. A lead-in conductor assembly as claimed in claim 3, in which the inner tube of the outer conductor member is replaced by an insulating covering on the outer surface of the central tubular conductor member.

5. A lead-in conductor assembly as claimed in claim 2, in which the inner conductor member comprises two tubes through which cooling water is adapted to be passed and the outer conductor member comprises three co-axial tubes providing two annular spaces through which cooling water is adapted to be passed.

6. A lead-in conductor assembly as claimed in claim 5, in which the outer tube of the inner conductor member and the innermost tube of the outer conductor member are replaced by an insulating tube or one of said tubes is replaced by an insulating covering on the other.

7. In or adapted for use in an electrical apparatus as hereinbefore specified (other than a vacuum electric furnace) the arrangement, for the purpose set forth, of co-axial lead-in conductors without solid insulation therebetween except at the ends, substantially as shown in Fig. 1 of the accompanying drawings, and substantially as described with reference thereto, and with or without an insulating bushing (3).

8. In or adapted for use in an electrical apparatus as hereinbefore specified (other than a vacuum electric furnace) the arrangements of co-axial lead-in conductors adapted for fluid circulation therein, substantially as illustrated by Figs. 2 and 3 of the accompanying drawings and substantially as described with reference thereto.

Dated the 8th day of July, 1935.
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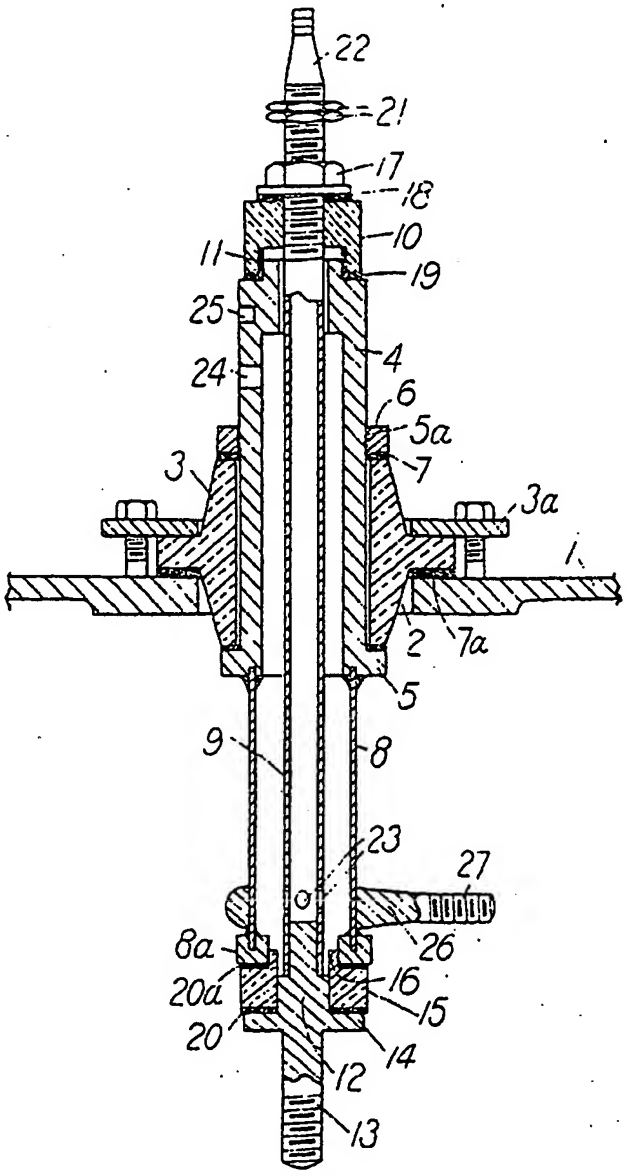
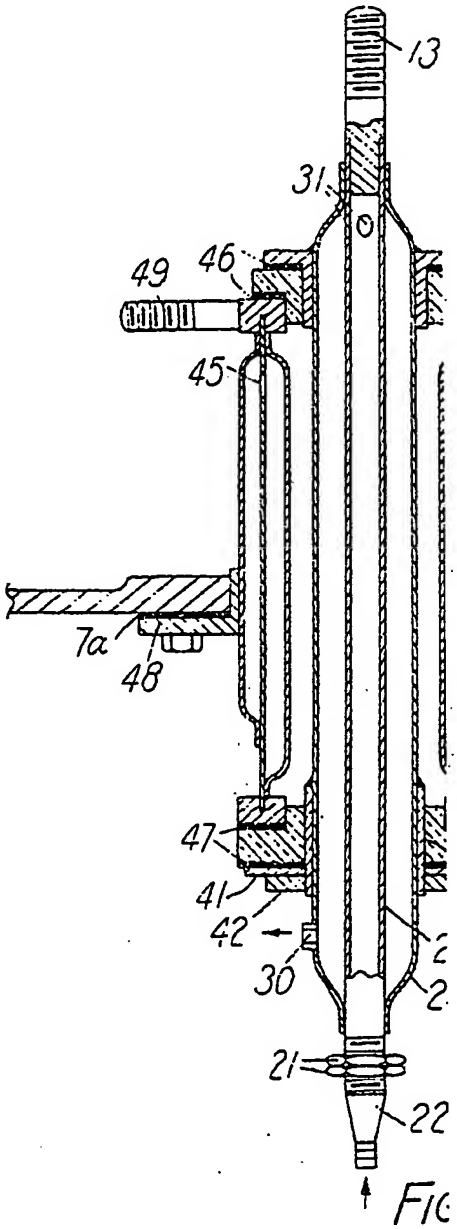


FIG. 1.



FIG

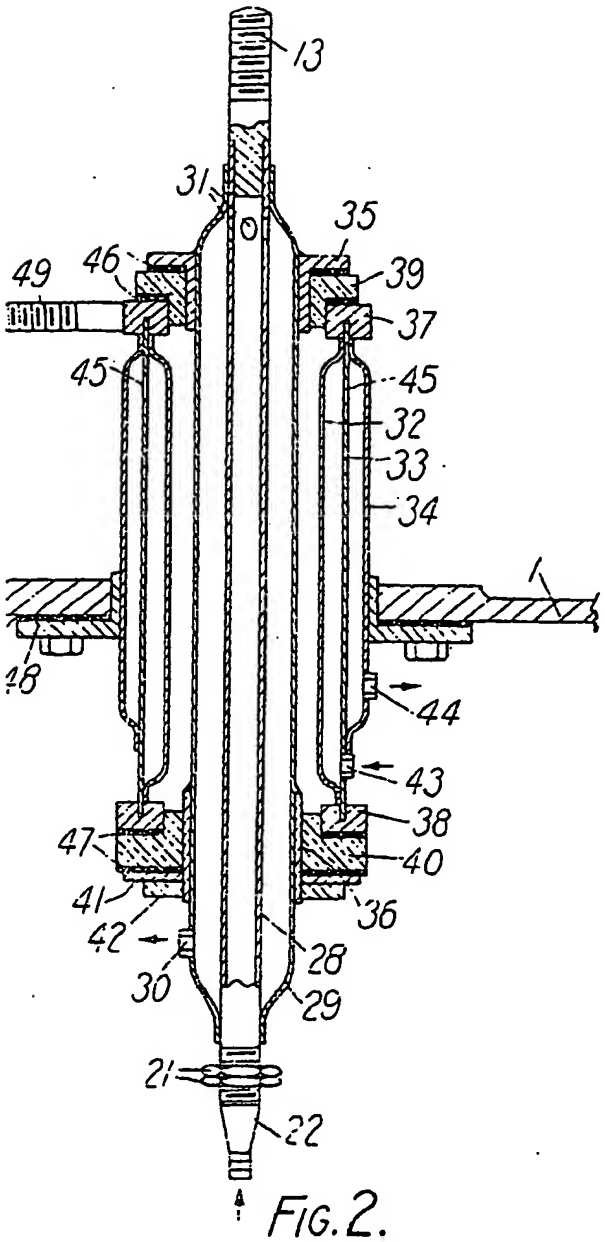


FIG. 2.

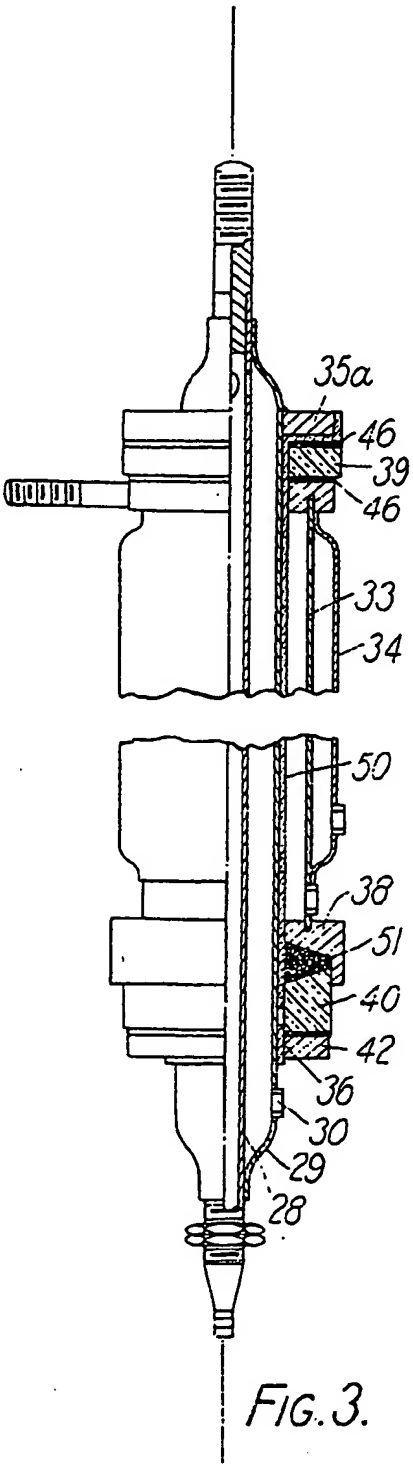


FIG. 3.

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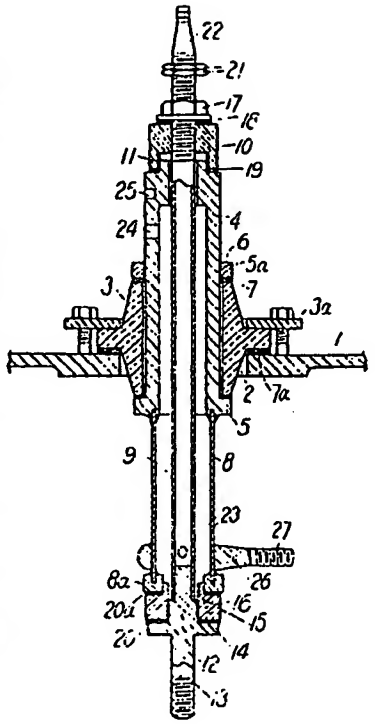

FIG. 1.

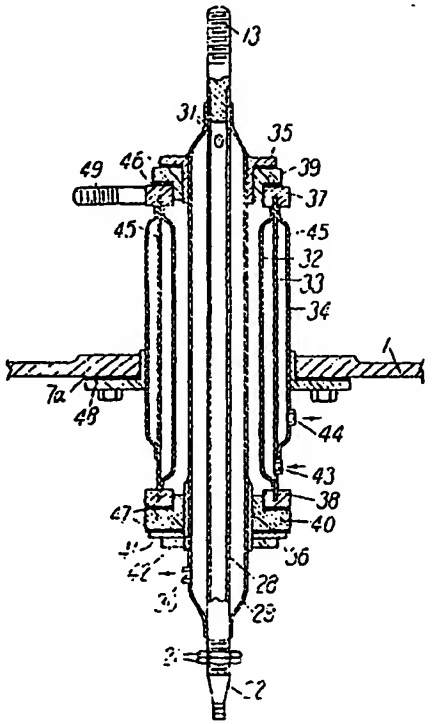

FIG. 2.

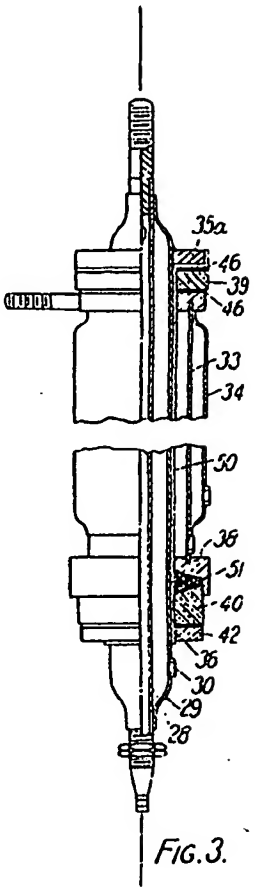

FIG. 3.

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